(12) UK Patent Application (19) GB (11) 2 204 162 (13) A

(43) Application published 2 Nov 1988

(21) Application No 8807437

(22) Date of filing 28 Mar 1988

(30) Priority data
(31) 8707395 (32) 27 Mar 1987 (33) GB

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(51) INT CL⁴
G06F 15/24

(52) Domestic classification (Edition J):
G4A UX
U1S 1189 1833 G4A

(56) Documents cited
US 4514815 US 4153931

(58) Field of search
G4A
Selected US specifications from IPC sub-class
G06F

(54) Equipment management system

(57) An equipment management system for use with weapon systems on submarines. Such systems involve large numbers of equipment items which require repair, replacement, updating etc in circumstances which may not be conducive to accurate log-keeping of the 'build' state of the system. The invention provides an integrated monitoring system in which each item is provided with a unique bar code which can be read by a hand held scanner while the item is in situ or in store. A portable computer keeps files, Fig. 3, of the complete inventory, the build state of the particular installation, and the equipment 'movements' over a particular period. A report can be issued as a print-out or Smart-card content on returning to port, to give the complete up to date equipment situation.

FIG.3

FILE	CONTENTS
MASTER INVENTORY FILE	LIST OF ALL UNIQUELY BAR-CODED MK.24 WEAPON SYSTEM ITEMS DELIVERED TO M.O.D THE FOLLOWING DATA IS HELD PER ITEM :- (a) B.C.N. (BAR-CODE SERIAL Nº) (b) N S N (c) M R I Nº (d) MANUFACTURERS SERIAL Nº (e) TITLE (ITEM NAME) (f) MODIFICATIONS IMPLEMENTED (g) DRAWING Nº (h) DRAWING Nº ISSUE
BUILD STATE FILE	(a) BUILD FAMILY TREE STRUCTURE LOCATION CODES (b) BCN OF ITEM FITTED TO EACH LOCATION
MATERIAL MOVEMENT FILE	(a) SERIALISED LIST OF S2022(S) RAISED PER PERIOD (b) LIST OF DEFECTIVE ITEMS ON-BOARD (c) LIST OF SUB-STANDARD ITEMS ON-BOARD

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The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.

FIG.1

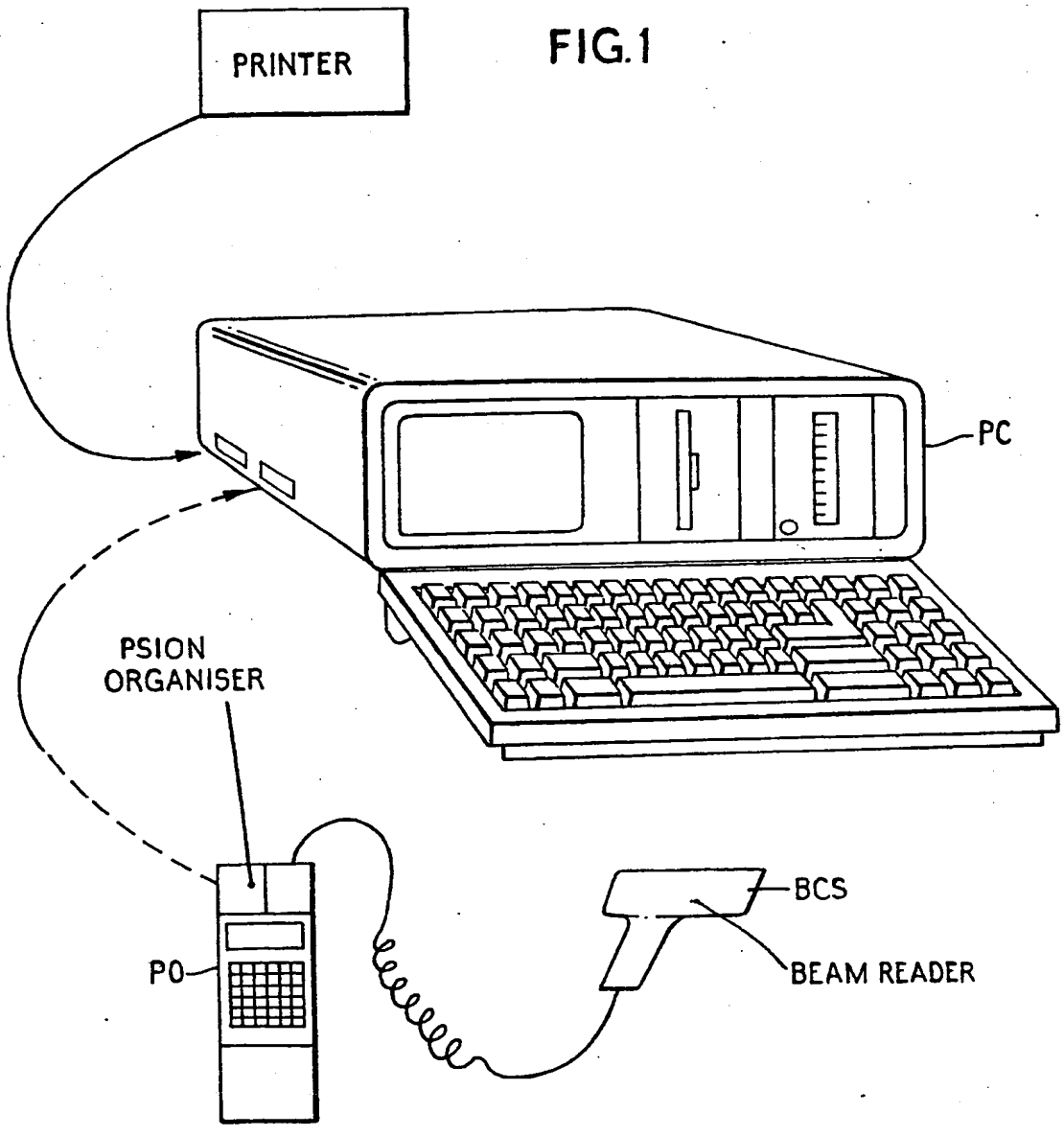
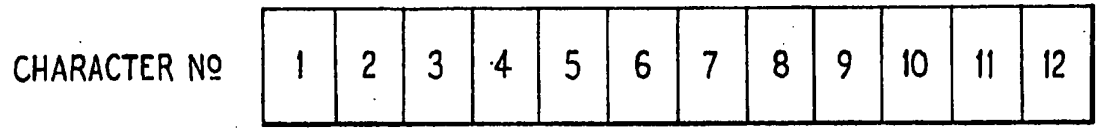


FIG.2



1	START	– INDICATES BEGINNING OF CODED SEQUENCE
2	PROJECT	– UP TO 36 PROJECT INDICATORS AVAILABLE
3	SUB-SYSTEM	– UP TO 36 SUB-SYSTEM DESIGN AUTHORITY INDICATORS AVAILABLE
4	CLASS - e.g.	– SUBMARINE , D.C.B., D.C.C., S.S.10 ETC.
5 TO 11	SERIAL Nº	– UNIQUE ITEM SERIAL NUMBER
12	STOP	– INDICATES END OF CODED SEQUENCE AND CHECK SUM

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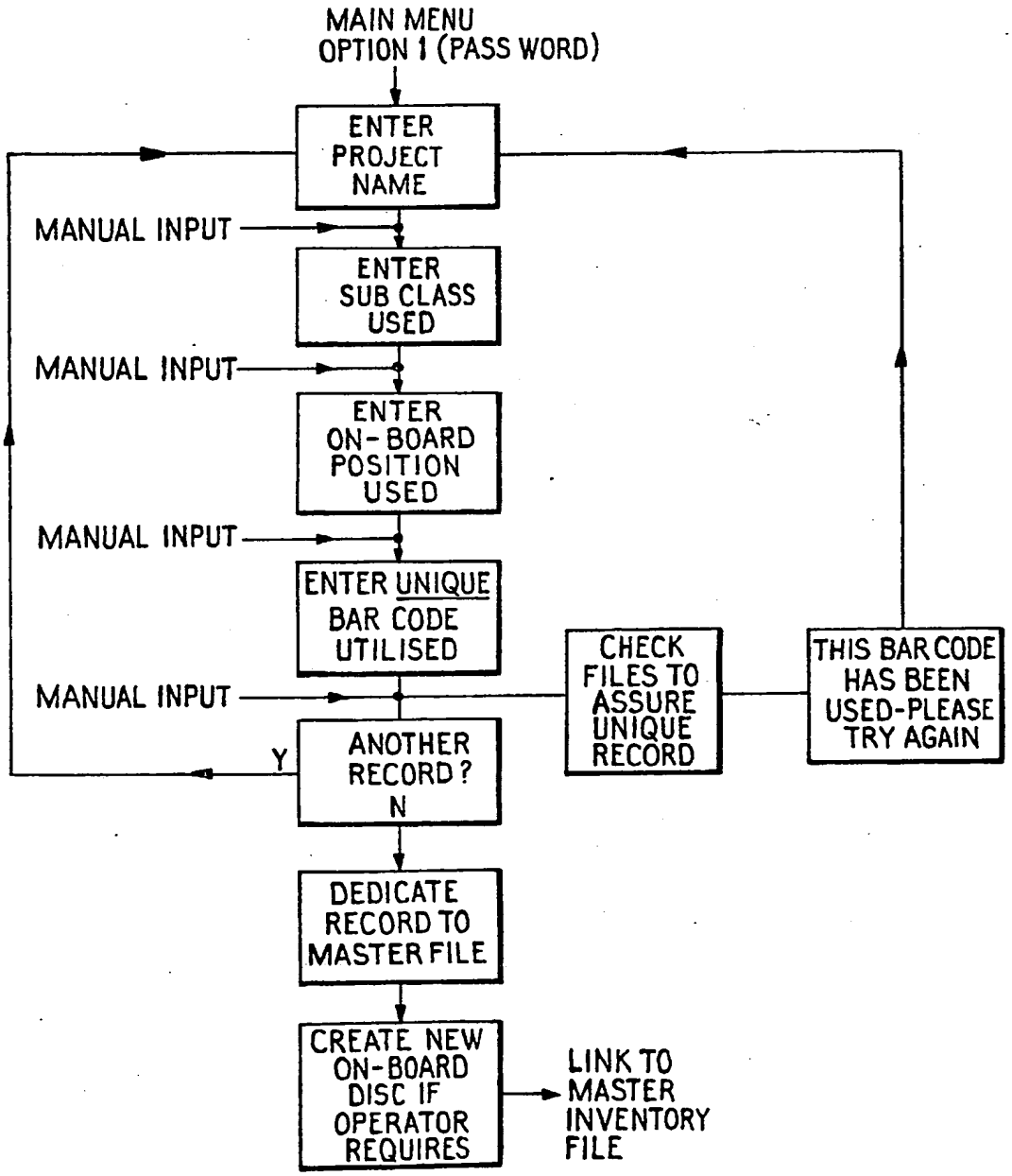
FIG.3

FILE	CONTENTS
MASTER INVENTORY FILE	LIST OF ALL UNIQUELY BAR-CODED MK.24 WEAPON SYSTEM ITEMS DELIVERED TO M.O.D THE FOLLOWING DATA IS HELD PER ITEM:- (a) B.C.N. (BAR-CODE SERIAL Nº) (b) N S N (c) M R I Nº (d) MANUFACTURERS SERIAL Nº (e) TITLE (ITEM NAME) (f) MODIFICATIONS IMPLEMENTED (g) DRAWING Nº (h) DRAWING Nº ISSUE
BUILD STATE FILE	(a) BUILD FAMILY TREE STRUCTURE LOCATION CODES (b) BCN OF ITEM FITTED TO EACH LOCATION
MATERIAL MOVEMENT FILE	(a) SERIALISED LIST OF S2022(S) RAISED PER PERIOD (b) LIST OF DEFECTIVE ITEMS ON-BOARD (c) LIST OF SUB-STANDARD ITEMS ON-BOARD

FIG.4

LOCATION DATA FILE

1) PROJECT STRING (15 CHARACTERS ALLOTTED)
2) SUBMARINE CLASS STRING (10 CHARACTERS ALLOTTED)
3) LOCATION STRING (20 CHARACTERS ALLOTTED)
4) BAR CODE STRING (13 CHARACTERS ALLOTTED)



LIBRARY DATA FILE

FIG.5

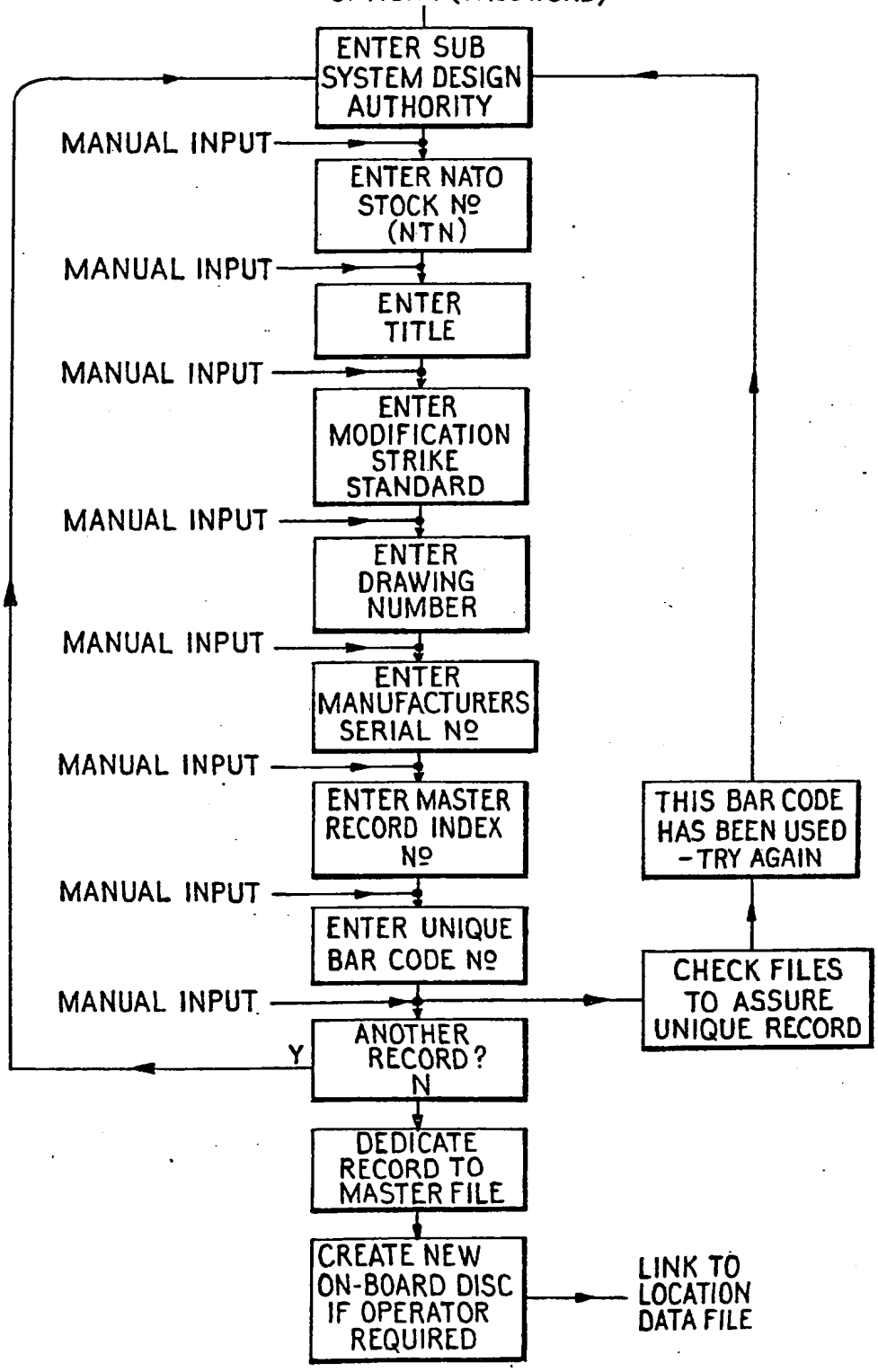
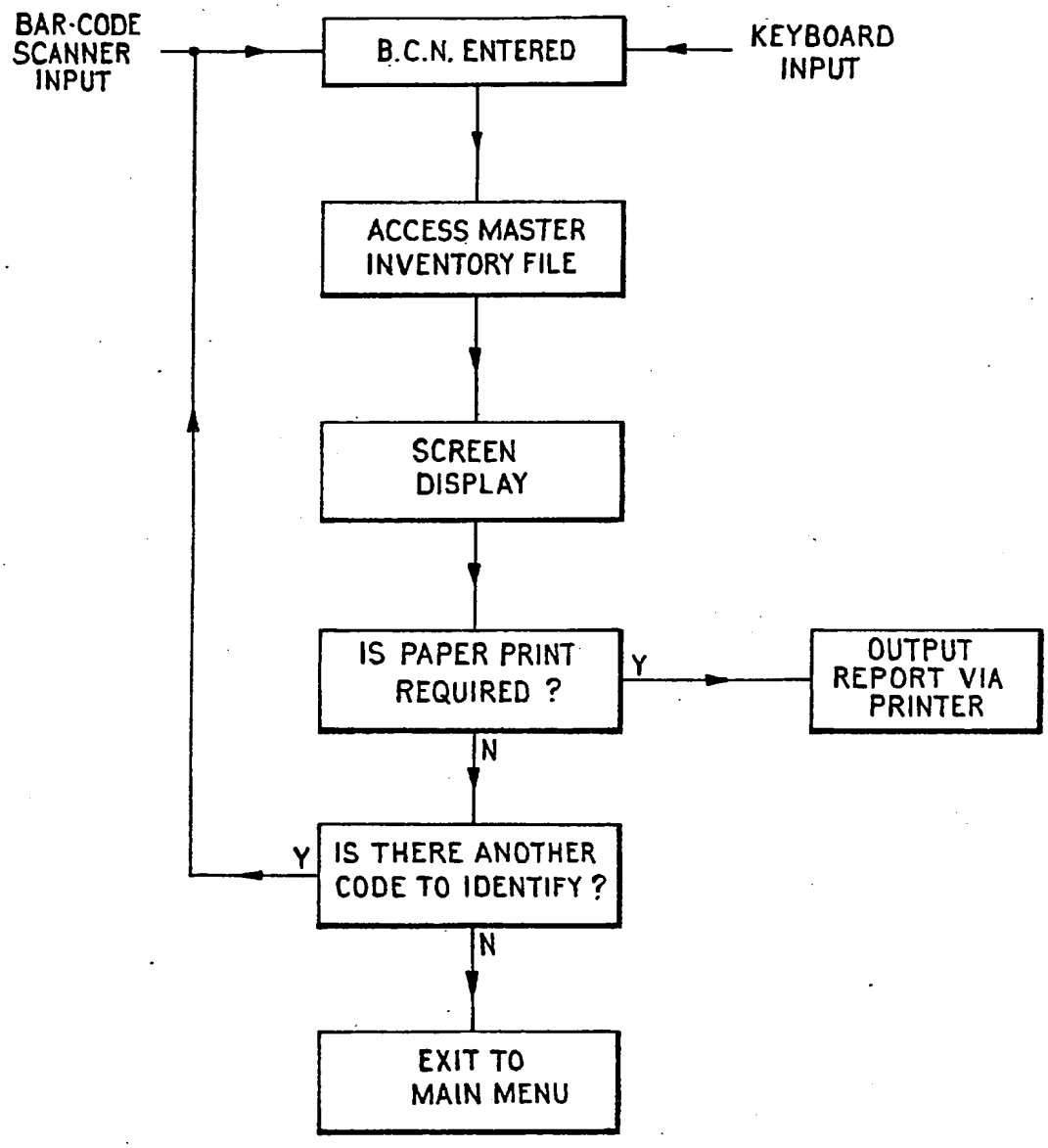


FIG.6


BAR-CODE SCANNER INPUT
B.C.N. ENTERED
KEYBOARD INPUT
ACCESS MASTER INVENTORY FILE
SCREEN DISPLAY
IS PAPER PRINT REQUIRED ?
Y
OUTPUT REPORT VIA PRINTER
N
Y
IS THERE ANOTHER CODE TO IDENTIFY ?
N
EXIT TO MAIN MENU

SELECT FROM 2ND MENU
OPTION REQUIRED

1) ITEMS IN USE
2) ON BOARD SPARES
3) DEFECTIVE ITEMS
4) RETURN TO MAIN MENU

FIG.7(a)

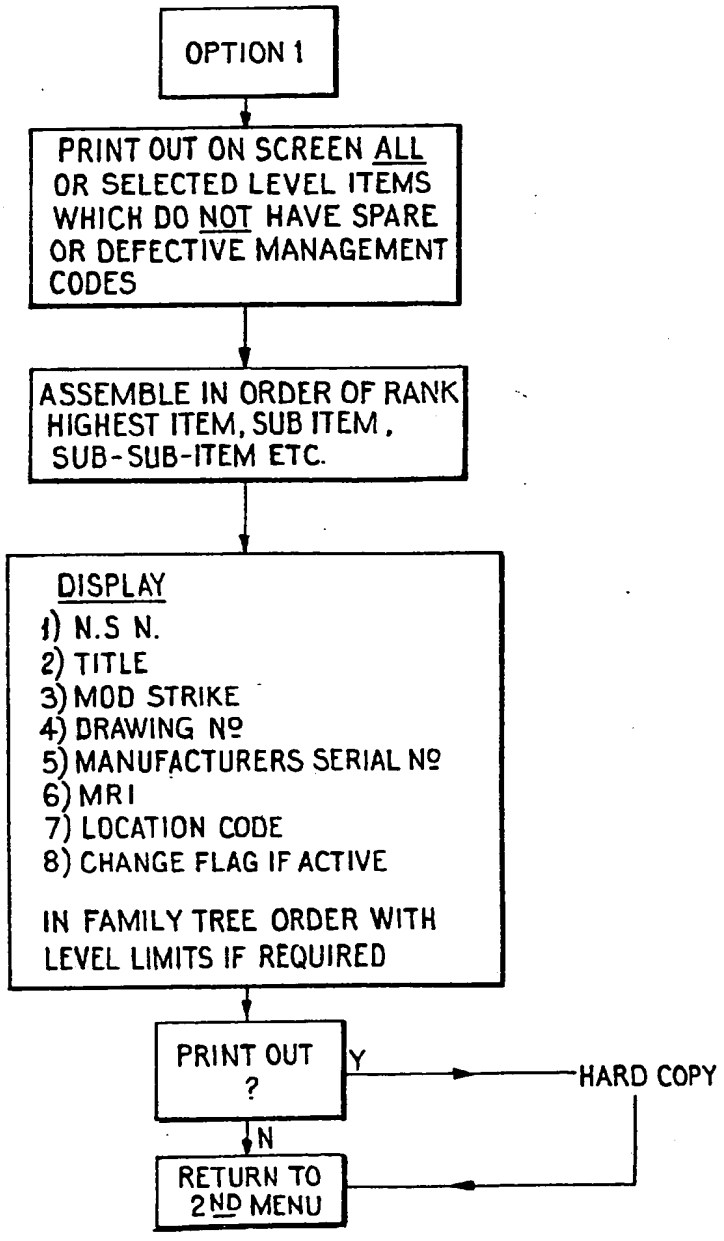


FIG.7(b)

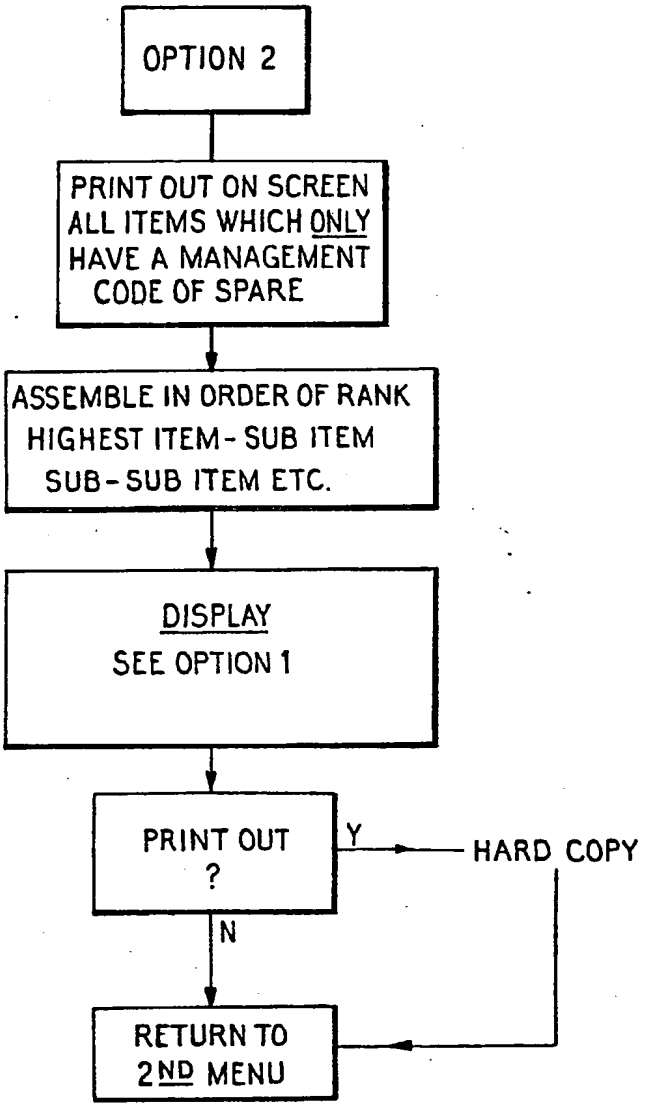

OPTION 2
PRINT OUT ON SCREEN ALL ITEMS WHICH ONLY HAVE A MANAGEMENT CODE OF SPARE
ASSEMBLE IN ORDER OF RANK HIGHEST ITEM - SUB ITEM SUB - SUB ITEM ETC.
DISPLAY
SEE OPTION 1
PRINT OUT ?
Y
HARD COPY
N
RETURN TO 2ND MENU

FIG.7(c)

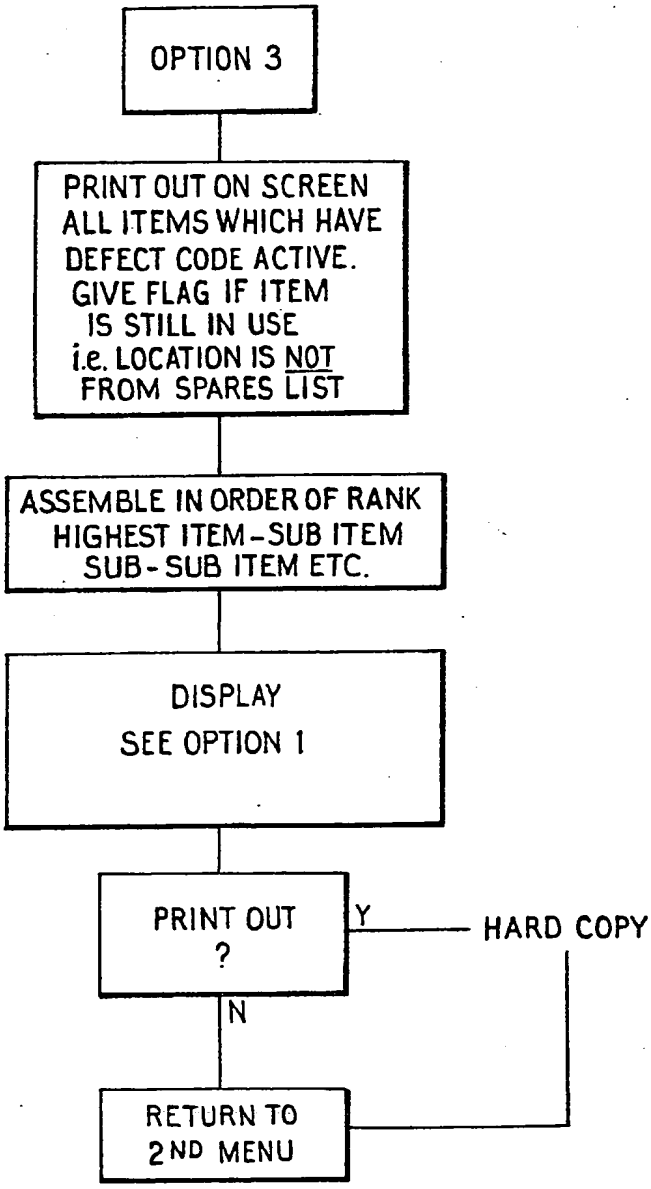
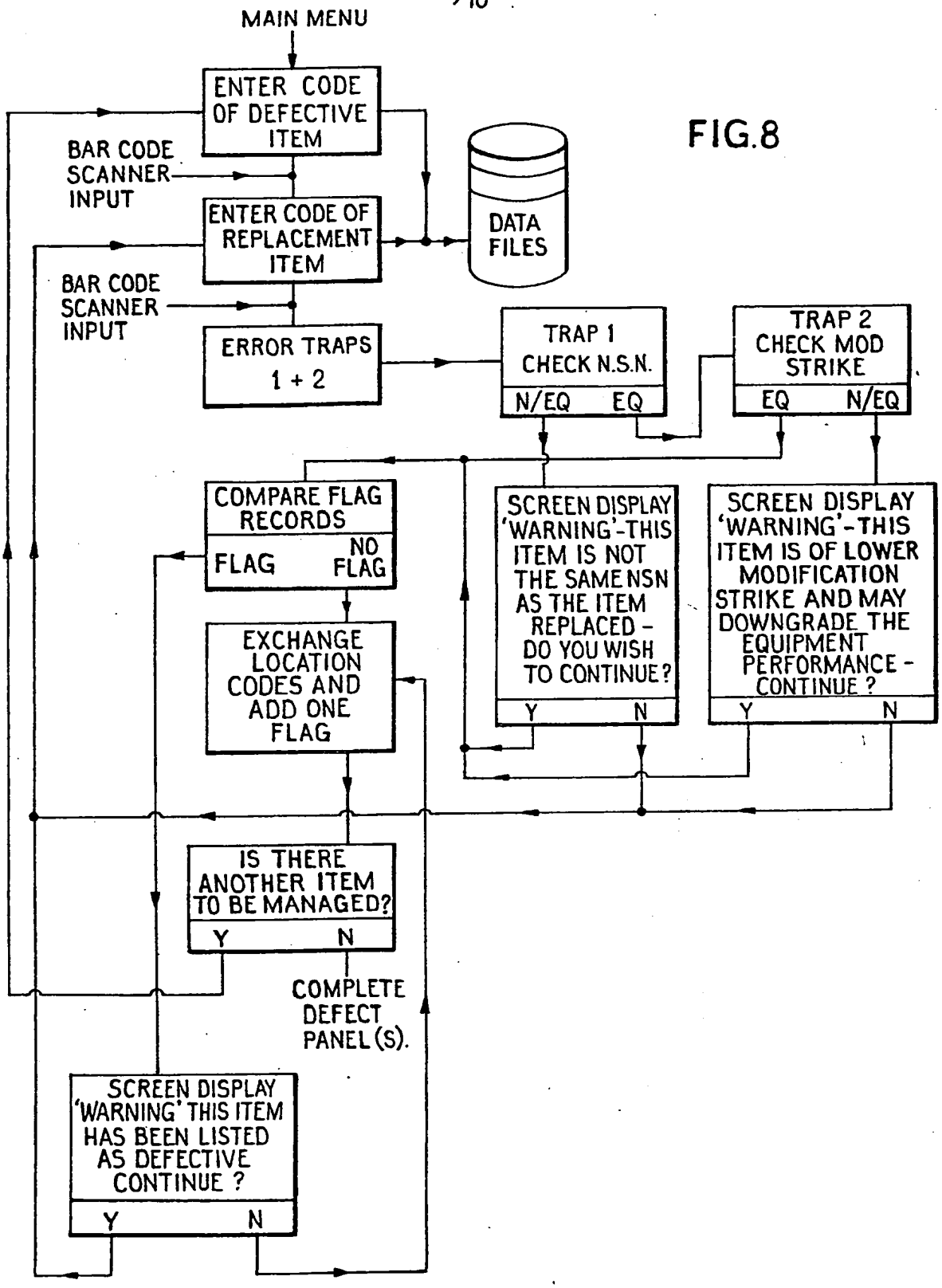

OPTION 3
PRINT OUT ON SCREEN ALL ITEMS WHICH HAVE DEFECT CODE ACTIVE. GIVE FLAG IF ITEM IS STILL IN USE i.e. LOCATION IS NOT FROM SPARES LIST
ASSEMBLE IN ORDER OF RANK HIGHEST ITEM-SUB ITEM SUB-SUB ITEM ETC.
DISPLAY SEE OPTION 1
PRINT OUT ?
Y
HARD COPY
N
RETURN TO 2ND MENU

FIG.8


MAIN MENU
ENTER CODE OF DEFECTIVE ITEM
BAR CODE SCANNER INPUT
ENTER CODE OF REPLACEMENT ITEM
DATA FILES
BAR CODE SCANNER INPUT
ERROR TRAPS 1 + 2
TRAP 1 CHECK N.S.N.
N/EQ EQ
TRAP 2 CHECK MOD STRIKE
EQ N/EQ
COMPARE FLAG RECORDS
FLAG NO FLAG
SCREEN DISPLAY 'WARNING'-THIS ITEM IS NOT THE SAME NSN AS THE ITEM REPLACED - DO YOU WISH TO CONTINUE?
Y N
SCREEN DISPLAY 'WARNING'-THIS ITEM IS OF LOWER MODIFICATION STRIKE AND MAY DOWNGRADE THE EQUIPMENT PERFORMANCE - CONTINUE ?
Y N
EXCHANGE LOCATION CODES AND ADD ONE FLAG
IS THERE ANOTHER ITEM TO BE MANAGED?
Y N
COMPLETE DEFECT PANEL (S).
SCREEN DISPLAY 'WARNING' THIS ITEM HAS BEEN LISTED AS DEFECTIVE CONTINUE ?
Y N

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MUP/3196

Equipment Management System

This invention relates to an equipment management system and particularly to one for use in circumstances where the operational environment is at least at times out of touch for all practical purposes with its supply and maintenance base. Such circumstances arise in the operation of ships and submarines away from their base stations.

Modern submarines incorporate extremely complex equipment which is required to be maintained and updated to a minimum standard specified by the Design Authority. The difficulty of maintaining this standard in operational conditions, particularly on active service, and keeping track of the current 'build state' as it is called (i.e. the content, identity, status and location of the equipment incorporated) is an enormous task which may easily get out of hand in difficult operation circumstances.

The Design Standard may be and is frequently defined in a Record Index. By structuring the design in a family tree format and identifying each family tree item as a serialised Record Index item, the design is broken down into a series of more easily manageable units. Unfortunately, the design of equipment is constantly being

changed in order to:

(a) eliminate defects

(b) improve performance

(c) meet new criteria (requirements) and

(d) cater for obsolescence.

Introduction of these changes at the design stage is readily achievable by application of well-recongnised control procedures which ensure their introduction into future production. However, problems can occur when the changes need to be embodied into already delivered hardware remote from the manufacturer's site. They concern the provision to the Design Authority of assurance that the equipment build state is maintained as near as is practicable to the highest achievable build standard.

As an example of such a case the difficulty of managing the in-service build-state of a submarine weapon system may be considered. The problems experienced are in three areas -

(a) establishing the actual build state

(b) recording the movements of replaceable parts both shore-to-boat-to-shore and within the weapon system on-board.

(c) Ensuring Weapon System effectiveness by control of the build state.

The deficiences in the above three areas in conventional systems are listed below.

Build State Recording

Labels not visible on hardware.

Modifications embodied inaccurately recorded on the modification labels.

No available recall of build state on-board.

No control of build state to a Minimum Build Standard requirement.

Necessitates expensive physical data gathering (known as "Fingerprinting") to determine build state.

'Fingerprinting' requires removal of items to ascertain build state.

Retest required.

'Fingerprinting, is only effectively managed at submarine overhaul periods.

Material Movement Recording

i.e., completion of a Material State Form for each movement or defect of an item.

Heavy paperwork functon at a time when operational requirements have priority.

Not always recorded for each movement.

Data incomplete on many Material State Forms.

Not used by dockyards.

Slow feedback of data.

Manually intensive with negligible system support.

Weapon System Configuration Management

Not possible to maintain control of build state.

System build state and hence effectively may be degraded.

Slow feedback of data hence slow corrective action for build state degradation.

Use of old pre-implementation spares not effectively controlled.

Periodic re-fingerprinting expensive.

According to the present invention, an equipment management system, for use in an operational environment independent of a supply and maintenance base, comprises a unique machine-readable code, identifying and physically associated with each respective item of equipment, computer means for storing a list of identity codes of all said items of equipment with indications of status and location, the status including indications of whether in use or spare and whether effective or defective, and the computer means being adapted to provide a listing of operative equipment, spare equipment and defective equipment.

The machine-readable code is preferably a bar code which represents, in addition to a unique serial number, information as to the system with which the item of equipment is associated.

The computer means may be accessible by the bar code, either as read by a portable scanner, or as input from a keyboard. The keyboard can be used to access further information required to be

stored, such as status and locations of items of equipment, into the computer.

A system in accordance with the invention enables the difficulties listed above to be overcome by means of a database system of inter-active files on the basis that each item of equipment as recorded is uniquely identified by a bar coded serial number (BCN) which is associated with other information required to be accessed, as indicated below.

The invention will be further explained by way of example with reference to Figures 1 to 8 of the accompanying drawings, which represent one particular system in accordance with the invention.

The hardware example considered is an in-service equipment in which the design of replaceable items is controlled by a Master Record Index (MRI), the item type is identified by a NATO Stock No. (NSN) and its movement or report of failure is recorded for assessment/investigation by external authority on a Material State Report.

Referring to the drawings, Figure 1 shows that in this particular application the system, which will be referred to as the ABC (Automated Build-State Control) system, comprises a semi-portable personal computer PC and recording to BCN data is to be achieved remote from sources of mains electricity using a bar-code scanner BCS coupled with a hand held computer PO, (the psion organiser).

Referring to Figure 2, the ABC system uses a 12 character alpha-numeric bar code with each character defined as in the list below. The bar code symbology to be used is Code 3 of 9 as specified in MIL-STD-1189A. Each character may be one of 10 digits or one of 26 letters - thus each character has 36 possibilities.

Character No.	Definition
1	Start - indicates beginning of coded sequence.
2	Project/System - up to 36 projects may be defined.
3	Sub-System/Design Authority - up to 36 sub-systems may be defined.
4.	Submarine class.

Character No.	Definition
5 to 11	Unique serial number of each item within a sub-system/Design Authority's area. The seven digits give a limit of 10^7 items.
12	Stop - indicates end of coded sequence and check sum.

The above character definitions have been developed for a particular Weapon System. There are 36 variations per character and up to 12 characters giving 4.7×10^{18} individual bar-code numbers as a finite limit.

The number of characters and the bar-code symbology is adjustable for other particular applications.

System Structure

As mentoned above, the ABC system is based on 3 inter-active computer files. The contents of each file and the capabilities of the system are listed below.

Master Inventory File

This file as shown on Figure 3 is loaded with a complete listing of all BCN items within the system or project equipment to be controlled together with related design standard and build state data per item (including the minimum acceptable build standard).

Build State File

This file is loaded with a family tree build structure where each family tree slot has a BCN item fitted and the acceptable design item (NATO Stock Number -NSN).

Material Movement File

(referred to by the standard Material State Report form S2022(S))

Within this file is a list of all items (BCN) removed during a pre-set period together with the BCN of each replacement item. The file also contains storage of all Material State Reports (S2022(S)) raised to cover the above changes of hardware.

The attached simplified system diagrams show the relationships between the above files when used to support various Build State control tasks.

Figures 4 and 5 are flow diagrams illustrating the entry of

original data, change data and the assembly of master inventory discs;

Figure 6 is a flow diagram of the inputting of a bar code, by scanner or keyboard and the accessing/display of the associated data;

Figures 7(a), (b) and (c) are flow diagrams illustrating the print-out of build statements; and

Figure 8 is a flow diagram of an on-board management process or the change of location of equipment items.

Capabilities

By relating the data in the Master Inventory File to the data in the Build State File the following reports are available:

(a) Full description of any item on-board by simply feeding into the personal computer PC the BCN of the item.

(b) Full list of items in any part of the as-built hardware system.

(c) Full list of items (structured to the family tree) in the whole system or sub-system of hardware as-built.

By relating the Material Movement File to the other two files the following outputs are achievable:

(a) An indication of any change of hardware.

(b) List of items in a sub-system or system showing locations of all hardware changes during a pre-set period (including the facility to show on the list of items how many times a replacement item was required in a particular location).

(c) List of all defective items within the hardware system.

(d) Warnings to the operator should he attempt to fit the wrong item or an item below the minimum acceptable build standard.

(e) List of all items in use below the minimum acceptable build standard.

(f) It is possible to further develop the system to identify areas of performance degradation predicted as a result of fitting replacement items of a build state lower than the minimum acceptable build standard.

The ABC System in accordance with the invention thus offers

a means of monitoring the changes to hardware in the field. In the case of electronic equipment forming part of the hardware, (d) or (f) above could activate an inhibit switch and prevent the equipment from being used until the correct item or correct standard of item is fitted.

The solutions provided by the invention to the problems highlighted above, are as illustrated below :-

Existing Equipment	ABC System
(a) Build state labels not visible.	All Bar-code labels will usually be visible except those behind sealed bulkheads, but data visibility will, in any case, be available on the computer screen.
(b) Modifications not maintained.	The Master Inventory File will be maintained in parallel with any changes to the hardware build state.
(c) No central log of build state on-board.	On-board PC holds complete fingerprint of the weapon system on-board.
(d) No control of build state to MBS. (Minimum Acceptable Build Standard).	MBS criteria pre-programmed into on-board PC.
(e) Fingerprint requires removal and refit of items to ascertain build state data.	All BCN visible in installed position therefore no requirement to remove and refit. Fingerprint held on PC.

Existing Equipment	ABC System
(f) Re-test required.	No removal of hardware for fingerprint hence no retest required.
(g) Fingerprint expensive manual operation.	Cheap floppy disc output of complete system, sub-system or part sub-system print-out from PC.
(h) Fingerprint only manageable at refit or maintenance periods.	Fingerprint data available any time from PC.

In complex, electronic equipment containing a suitable central processing unit (CPU) it is possible to make use of the CPU computer in place of the portable computer of the ABC system described and couple the bar-code scanner directly to the CPU.

On accessing the system for build state recording the output report may be provided on a floppy disc or applied to a so-called Smart card, an active data storage 'card'.

It will be appreciated that although the invention is aimed primarily at providing information regarding submarine equipment, it may also be used to advantage in other vessels which may be away from their base stations for prolonged periods.

CLAIMS

1. An equipment management system for use in an operational environment independent of a supply and maintenance base, the system comprising a unique machine-readable code, identifying and physically associated with each respective item of equipment, computer means for storing a list of identity codes of all said items of equipment with indications of status and location, the status including indications of whether in use or spare and whether effective or defective, and said computer means being adapted to provide a listing of operative equipment, spare equipment and defective equipment.

2. A system according to Claim 1, wherein said machine-readable code is a bar code which represents, in addition to a unique serial number, information as to the system with which the item of equipment is associated.

3. A system according to Claim 2 incorporating a keyboard for introducing information as to the status and location of the equipment into the computer means.

4. A system according to Claim 3, wherein said computer means is accessible by said bar code, either as read by a portable scanner, or as input from said keyboard.

5. A system according to Claim 2, 3 or 4 wherein the computer means comprises a semi-portable computer.

6. A system according to any one of Claims 2 to 5 wherein the bar code is a 12 character alpha-numeric bar code.

7. A system according to Claim 6 wherein each character is one of 10 digits or one of 26 letters.

8. A system according to any preceding Claim incorporating, within the computer store, a first file containing a listing of all items of equipment, as a unique bar-coded serial number, with relevant data thereon, a second file designed to contain details of locations

of the items, and a third file designed to contain details of any changes to said items, and of any defects therein.

9. A system according to Claim 8 wherein the computer means is programmed to compare the build-state of each said item with the minimum acceptable build-state, and to provide an indication of any item which is below the minimum acceptable build-state.

10. A system according to Claim 9 incorporating for electronically controlled equipment an inhibit switch operable to prevent the functioning of the equipment, and the computer means is programmed to generate a control signal for effecting the operation of the inhibit switch in the event that the reading of the bar-code of an installed item shows that an item of incorrect standard or an incorrect item has been fitted to the equipment.

11. An equipment management system substantially as shown in, and as hereinbfore described with reference to, Figures 1 to 8 of the accompanying drawings.

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